Investigating GTA Beliefs That Might Reinforce Inequity in Pre/Calculus Courses

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In this preliminary study, we examine the beliefs of graduate teaching assistants and investigate how seemingly identity-neutral beliefs may reinforce deficit narratives in precalculus and calculus courses. Drawing on the Attributions of Mathematical Excellence (Jacobson et al., 2022), we report the analysis of one participant's attributional beliefs and how they may explicitly and subtly reify deficit discourses. Our findings underscore the need for critical conversations about instructor beliefs regarding success and struggle in undergraduate pre/calculus. We recommend training programs provide graduate teaching assistants the opportunity to engage in reflective dialogue to identify opportunities to disrupt harmful narratives in undergraduate mathematics education.

Keywords: Equity, Beliefs, Calculus, Precalculus, Teaching Assistants

Deficit narratives are built around mathematics being perceived as "objective" and "universal"; thus, all students are expected to experience mathematics in the same way. When students, especially those in marginalized groups, do not ascribe to the master narrative of mathematical experiences, educators often hold learners personally responsible for their struggles and underachievement while also refusing to make visible the mathematical understandings the students do hold (Adiredja & Louie, 2020). With this narrative in mind, instructors can often tout a racial- and gender-neutral perspective in mathematics. While this mindset can be seen as an avenue to mitigate harm based on identity, Leyva et. al. (2021) argues that students can still interpret their experiences in the classroom as racialized or gendered, even when race and/or gender is not explicitly mentioned in their classroom. The classroom environment is shaped by the instructional practices instructors utilize, and as prior research has empirically shown, teacher beliefs have a significant impact on their instructional practices (Schommer, 1990; Pajares, 1992; Wilhelm et al., 2017). Therefore, our research seeks to explore instructors' beliefs regarding mathematical success and struggle in college precalculus and calculus classrooms. Our research goal is to shine a light on instructors' beliefs that might explain why "seemingly neutral behaviors and comments" (Leyva et al., 2021) might reinforce or disrupt racist and sexist disparities in precalculus and calculus, especially among new and early career instructors in higher education. The goal of this report is to share preliminary results of our work towards our broader research goal, by sharing our analysis of one participant's beliefs along with a discussion on how those beliefs explicitly and subtly reify deficit narratives about students. We focus on precalculus and calculus because those undergraduate courses tend to serve as gatekeepers and impact interest and career choices within the STEM fields (Riegle-Crumb & Humphries, 2012; Levya et al., 2021).

Empirical Background and Theoretical Framework

Deficit discourses in mathematics education attribute faults in students' academic success and intellect to perceived defects of the student or their community (Adiredia & Louis, 2020). For example, some deficit discourses in mathematics education claim that Black and Latinx students are responsible for their own underachievement (Nasir & Shah, 2011), that "women and

Latinos are not good at mathematics" (Leyva, 2016, p. 109), or that Mexican and Black families and cultures do not value schoolwork (Solórzano & Yosso, 2002; Adiredia & Louie, 2020).

Recently, Jacobson et al. (2022) used theories from social psychology to characterize these deficit and anti-deficit discourses in mathematics education with their attributions of mathematical excellence (AME) framework. Within this framework, an attribution is a belief about a perceived cause to an effect. The AME framework allows researchers to characterize the attribution beliefs teachers hold about students' mathematical success or struggle into types informed by larger deterministic beliefs that tie back to the deficit discourses in mathematics education. There are four categories of attributions in the AME framework: genetic, personal, social, and educational. The genetic category, informed by the theory of Genetic Determinism (Keller, 2005), describes attributions with factors related to a student's genetics, like biological sex. The personal category, informed by the theory of School Meritocracy (Wiederkehr et al., 2015), describes attributions with factors related to students' personal characteristics, like effort. The social category, informed by the theory of Social Determinism (Rangel & Keller, 2011), describes attributions with factors related to students' upbringing and socialization. Lastly, the educational category describes attributions with factors related to students' prior educational opportunities. AME are thought to be productive in that AME-E challenges deficit discourses, or unproductive (all other types) which contribute to deficit discourses +. Importantly, the AME framework highlights how seemingly identity-neutral attribution beliefs correspond with negative racial and gender stereotypes (Jacobson et al., 2022). For example, the explanation that greater effort begets academic success (AME-personal) corresponds with the discourse in mathematics education about Black and Latinx students being underachievers. We seek to answer the research questions: *What are graduate instructors' beliefs around mathematical success and struggle in the context of precalculus and calculus?* and *In what ways do graduate instructors' beliefs about mathematical success and struggle reify or challenge deficit discourses in the context of precalculus and calculus?*

Methods

We employed a basic qualitative research design for this project (Merriam, 2015). We purposefully selected graduate teaching assistants serving as instructors for precalculus and calculus courses, because they are typically responsible for leading recitations, which generally involve greater interaction between students and instructors. In total, we interviewed four graduate students who were all enrolled in a doctorate program in mathematics, with different concentrations. The data for this research was collected using semi-structured zoom interviews designed to investigate teachers' attributional beliefs about the causes of students' successes and struggles in mathematics. Interview questions focused on what each participant believed to be the underlying cause of their students' successes or struggles in (pre)calculus courses. For example, the interview included questions like, "Why do some students succeed in (pre)calculus while others struggle?" Based on our prior work, (Roan et al., 2025), we anticipated that our participants' beliefs would be interconnected so we used follow-up questions such as, "Why do you think this happens?" which aimed at determining clusters of influential factors. To analyze the data, we categorized the attributions made in the interview based on the categories in the AME framework: Genetic, Social, Personal, and Educational. To explore the interconnectedness of our participants' attributions, we conducted causation coding (Saldana, 2021), which was used to create a visual model of our participants' attributional beliefs. Working together, the research team coordinated to ensure that their individual coding efforts standardized. This type of collaboration provides what Saldana (2021) calls "crowd-sourcing reality checks" that increase

the interrater reliability and interpretive congruence ensuring code agreement. This process also allowed for the consensus in coding "dialogical intersubjectivity" (Saldana, 2021) of unclear causes provided by the participants. As Saldana (2021) contends, "this dialogic exchange of ideas in a workshop and collegial atmosphere attunes the research team to new and varying perspectives before more intensive scrutiny" (p. 53) as analysis of the data progresses. To identify chains of influential factors, we applied three aspects of causal coding during analysis based on Saldana (2021) recommendations. Following a structure that maps antecedent or starting conditions → mediating variables → outcomes, where the arrow (→) denotes what a causal relationship "leads to". Given that multiple causes can result in multiple outcomes, subcodes were employed to represent the complex, multidimensional nature of belief system networks. These codes were then translated into causal diagrams, which visually illustrate the intricate relationships that are often difficult to fully convey through text alone.

In this report, we share preliminary results of our analysis by sharing some results from the analysis of one participant, pseudonym Frida. Frida was a graduate teaching assistant in a mathematics department at a large midwestern university. She identified as female and white European. Frida was an instructional assistant leading recitation for calculus one and calculus two multiple times, but she had never explicitly taught Precalculus. Frida was an instructor of record for a course designed to be a brief introduction to calculus one time.

Results

In this report, we will highlight two prominent clusters of Frida's attribution beliefs, one that explicitly places a deficit on students, and one that does so subtly. We note that the attribution clusters as reported are not self-contained. These beliefs are connected to a larger belief system present in the data, but we do not share this larger system due to space.

Frida said that mathematical success is performing well in the course, learning the material well, learning to study mathematics, and applying oneself. When asked what factors influence students' mathematical success in calculus, Frida said

> . . . some of them, probably genetic environment, like genetic factors. Some people just have a higher IQ than others. I guess environmental influences. What level of math exposure have they had to in previous courses. What's the level of education their parents have had, like these environmental sociological factors. Genetic, obviously, too. And then, I guess where it boils down more to the student is, have they learned maybe efficient ways to think about math . . .

In this quote, Frida attributed students' mathematical success to a) genetic factors, such as baseline intelligence and lineage, b) educational factors, like students' prior educational experiences, c) social factors, like education level of the parents, and c) personal factors, like efficient learning, and experiences. For this report, we focus on the first two attributions from Frida's quote. Frida connected genetic factors and success in college calculus as follows:

> . . . the genetic influence, the IQ, there's probably very little you can do to change like that baseline intelligence. . . . I've seen that also in myself and classmates like at a certain point, like even with work, even with trying to like, apply good study strategies. There's that certain point where IQ just does play that significant role.

In the quote, Frida explained that students who are very successful in college calculus, from her perspective, have a very high "baseline intelligence". For her, baseline intelligence is a genetic trait. She noted that this does not necessarily mean that students with a "low IQ" cannot be successful in mathematics, only that they will always be less successful than their peers with a "high IQ". When asked to describe the students with a high IQ, Frida explained "I've kind of

noticed males either tend to be really high on the IQ spectrum, or a bit low, and females tend to be more average in the middle. That's just from what I've observed." In this quote, Frida made the connected attributions that biological sex influences whether a student has a "high IQ", which influences mathematical success.

Frida explained prior educational experiences and success in college calculus as follows "If some of them have say, taken AP calculus before. They're also able to get to that next level." In this quote, Frida acknowledges that students who have taken AP calculus in high school are more likely to "get to that next level" of understanding, an indicator she had previously stated as her evidence for if a student was successful. When asked to describe the students are who have taken AP calculus before, Frida said they "have parents that are maybe in STEM themselves" or are "students that know pretty early on in high school, they're going into STEM, or they're going to be a math major". Based on these quotes, we inferred that Frida made two attributions, that taking AP calculus in high school is influenced by 1) whether a student's parents are in STEM, and by 2) a student's interest in STEM. Due to space, we only detail the first attribution in this report. When asked to explain why the students' parents being in STEM influenced the students taking of AP calculus, Frida said

> When you grow up, what you see is the norm you observe. So, I guess, maybe just seeing that, being familiar with it [math], [makes math] probably less of an obstacle and barrier. . . maybe some natural advantage. [pause] They have the, I guess, personal help at home if they need it.

In this quote, Frida makes three different attributions. First, Frida made the attribution that having parents in STEM influences how STEM is normalized for students, which influences whether the student sees STEM as a barrier, which influences whether they take AP calculus in high school. Second, Frida made the connected attributions that having parents in STEM influences whether students have a natural advantage in STEM which influences whether they take AP calculus. We infer that Frida meant natural advantage to be genetic in nature. We made this inference based on her prior statements regarding the connection between students' mathematical success and their parents. Specifically, she said that the parents were related to "environmental sociological factors. Genetic, obviously, too". Lastly, Frida connected the attributions, having parents in STEM influences the quality of help received at home, which influences whether students take AP calculus in high school. Together, these attributions formed an attribution beliefs cluster where each outcome was attributed to a prior attribution outcome see Figure 1.

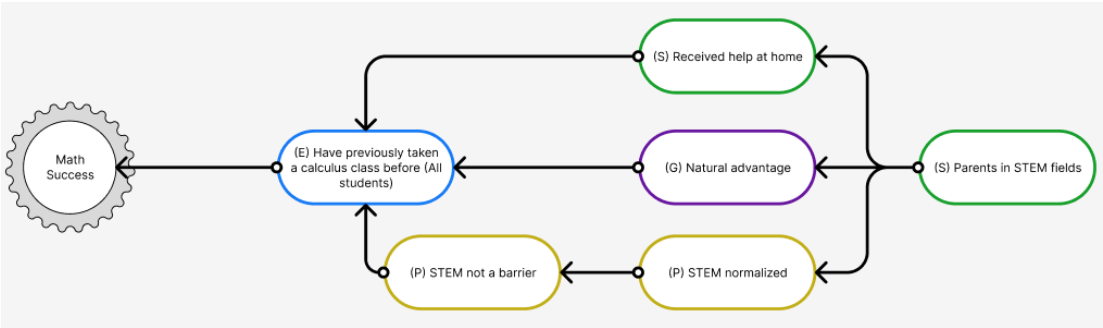

Figure 1 Part of Frida's attribution diagram that shows an anti-deficit explanation based in deficit explanations. The colors correspond to the categories of AME: Genetic (Purple), Social (Green), Personal (Yellow), and Educational (Blue).

Preliminary Nature of Proposal and Discussion

In this proposal, we presented an in-progress analysis of graduate teaching assistants' beliefs about the nature of success and struggle in mathematics education. Specifically, we reported two attribution clusters of one of our participants, Frida. In the first attribution cluster, Frida attributed biological sex to innate intelligence, which directly influences success in college calculus. From our interpretation, this attribution cluster shows beliefs that explicitly place a deficit on the student. She further explains that males tend to be high on the IQ scale while females tend to be average. This reifies the deficit narrative that women are innately less intelligent than men. In the second attribution cluster, Frida attributed success in college calculus to prior experience with calculus. This could be seen as an anti-deficit explanation of student success because Frida attributed students' success in college calculus to experiences in AP calculus in high school. That does not explicitly put a deficit upon the students nor their families. However, Frida connected experience in AP calculus to factors like having support for mathematics at home, feeling that STEM is not a barrier, and having a natural advantage, all of which stem from having parents in STEM fields. Those are unproductive explanations because Frida is attributing students' success to traits belonging either to the student or to their families. From our theoretical framework, this attribution cluster shows that productive beliefs based around educational opportunities can be traced back to deficit narratives, such as who belongs in STEM. Here, seemingly neutral attributions (i.e., parents in a STEM fields), when viewed through our theoretical lens, become linked to beliefs in genetic (Keller, 2005) and social determinism (Rangel & Keller, 2011). When put into the context of the ways in which women and people of color have historically been marginalized in STEM fields, Frida's belief becomes deficit in nature, steeped in both racist and sexist ideologies. This indicates that anti-deficit beliefs can be shaped by deficit narratives

Our findings also connect to the idea of "objectivity discourse", in which instructors consider experiences to be race- and gender-neutral, while concurrently acknowledging students' experiences differ (McNeill et al., 2022). McNeill et al. (2022) noted that holding conversations to address these perspectives can be useful. We agree with this notion and respond to the call by Jackson et al. (2017) to shift teachers' perspectives on their students' capabilities by recommending that instructors should be given the opportunity to reflect upon their beliefs regarding students' success and struggle. Given the population of our study, we focus our suggestion for graduate preparation programs. Prior research indicates that the level of pedagogical training for graduate students varies vastly per institution (Harris et al., 2009). Additionally, research on graduate teaching assistant training has focused on more cognitive aspects of teaching (e.g. Speer, Gutmann, & Murphy, 2005; Ellis, 2015). While there is research that target equity in math education through graduate assistant training (e.g., Taylor et al., 2025), we see a vital need for graduate programs to hold conversations around student success and failure, especially for instructors teaching gateway courses like precalculus and calculus.

We intend to continue data analysis and gather feedback from the RUME community. We welcome any feedback on the presentation of the data, particularly regarding the diagram in Figure 1. We also welcome feedback on connections to literature to support situating our study with the larger conversation regarding equity in undergraduate mathematics education. Lastly, we recognize that connections between the participants' beliefs and deficit narratives revolve around race and gender. Thus, we ask the reader: in what ways might we add a more critical lens within the research design and analysis?

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